

Creating Maps in QGIS: A Quick Guide

Overview

Quantum GIS, which is often called QGIS, is an open source GIS desktop application. Comparing to ArcGIS, QGIS can be installed on various operating systems, such as Windows, Mac OS X, Linux (Ubuntu), and Unix, while ArcGIS only has Windows version. More importantly, QGIS is FREE and has many plugins, adding different functions. However, since QGIS mainly relies on community support and voluntary developers, it does not have abundant documents and sometimes is not intuitive to use. Hence, making maps in QGIS needs some explanation. The two major steps, browsing data and making maps, are divided into five parts shown in the following table:

No.	Steps	Sections to check	Difficulties
1	Load Geospatial Data into QGIS	1.1	Data formats
2	Identify the features and attributes to present	1.3	Layer order, feature selection, and (briefly) frequent-used projections
3	Define how to show the data	2.2	Transparency (raster and vector), data classification, and layer file
4	Add maps components	2.3	Geospatial data references
5	Export maps	2.4	File formats

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Note: This document can be read in a “non-linear” manner:

- Possible problems are covered in coloured regions: Knowing how to address these problems are not quite relevant to the main process, but might be useful in practise. Hence, they are covered in coloured regions, which you can skip when you want to go through the process and no error pops up. You can come back whenever you meet problems;
- Section number and title is shown at the top of every page: If you have known what kind of problem you have, you can “jump” to the section where discusses it.

1.1 Load Data

1. Browse Geospatial Data

1.1. Load data

To launch QGIS, click: **Start -> All Programs -> QGIS -> QGIS**. QGIS normally adds the version number after “QGIS”, which is currently 1.5.0 (code name Tethys). The main windows of QGIS can be divided into three regions shown in Figure 1.

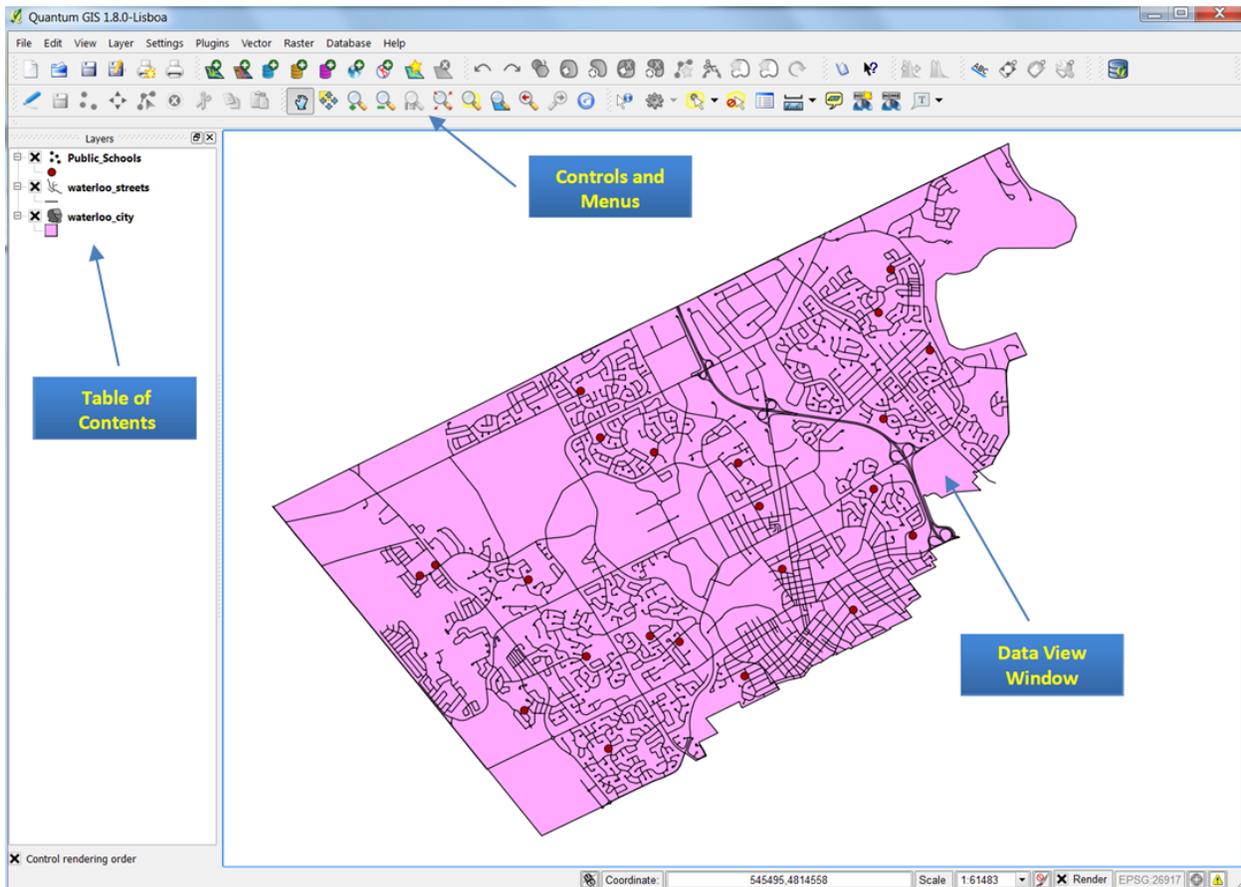


Figure 1. Structure of the Main Window of QGIS

Click the **Add Vector Layer**  button to add geospatial data (Figure 2), which opens a window (Figure 3).



Figure 2. The Main Window : Add Vector Layer button

1.1 Load Data

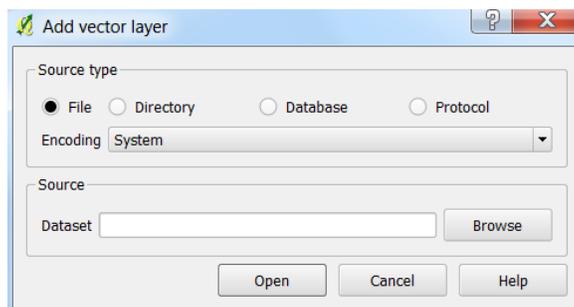


Figure 3. The Pop-up Window to "Add Vector Layer"

Then you can browse to the file you want to work with by clicking the **Browse** button just like any other file explorer dialogs in Windows. You can open multiple files at one time by holding the **Ctrl** or **Shift** button when you are clicking the mouse button to make selections. The by-default file filter is *.shp file (Figure 4). But there are many other choices, such as *.kml (Google Earth) and *.tab (MapInfo), much broader than ArcGIS.



Add Raster Data: QGIS explicitly differentiates vector and raster data format. To add raster data, the **Add Raster Layer** button  should be clicked. The main reason is that raster data is supported via another open source module called GDAL, which adds powerful operations or raster data processing.

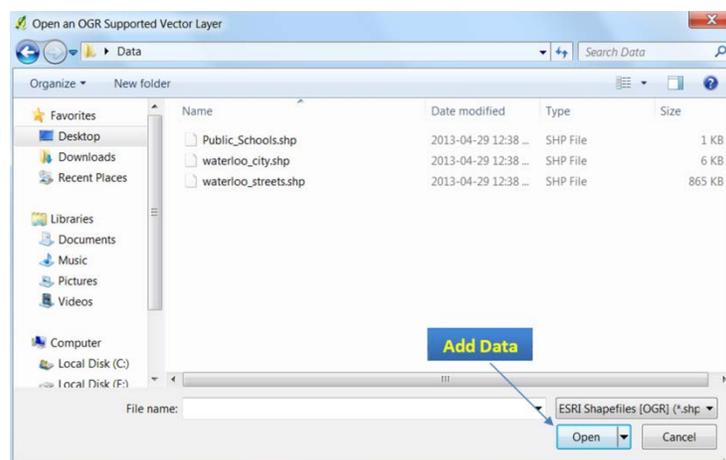


Figure 4. The File Open Dialog

Load all data listed in Figure 4 into QGIS. Please click the **Open** button just like any other file explorer dialogs in Windows to close the dialog.

- **Public_Schools.shp:** All public school locations in the City of Waterloo;
- **waterloo_city.shp:** The administrative boundary of the City of Waterloo;
- **waterloo_streets.shp:** Street network in the City of Waterloo

1.1 Load Data



Frequently-used File Formats in QGIS:

- **Feature Data:** Feature data are usually organized as points, lines, and polygons in vector format.
 - **Shapefile:** The most commonly used geospatial data format. Although it appears to be one file in ArcMap, shapefile includes **multiple files** with the same file name, but different extensions. *.shp, *.dbf, and *.shx are must-have.
 - **Geodatabase:** These files are based on Microsoft Access (*.mdb). From user perspective, all kinds of geodatabase are the same, which include multiple layers (different geospatial data) in one geodatabase.
 - **MapInfo files:** The following three are legendary geospatial file formats. MapInfo is the first desktop GIS software for Windows. Its files (*.tab) are widely used.
 - **MicroStation files:** MicroStation files have the extension of *.dgn, whose vendor is GE. Electricity plants often use it.
 - **ArcInfo:** ArcInfo is the previous generation of ArcGIS. Its file (*.e00) are supported in QGIS as well.
 - **Google Earth:** *.kml and *.kmz (zipped KML) are Google Earth file formats, which are popular in Location-Based Service now. Many websites support kml and kmz files.
 - **GML and GeoJSON:** Open source geospatial data standard, which is also popular in online applications.
 - **GPS:** The track of GPS records can be imported into QGIS as *.gpx files. This function is very useful in surveying.
 - **CSV:** *.csv files stands for comma separated value, which can be regarded as a legendary spreadsheet file format.
 - **US Census TIGER:** US census publishes its data in tiger format, which belongs to “directory” source type rather than “file”.
- **Raster Data:** Raster data uses grid to represent a region with values as a “field”. Images explicitly have the parameter of resolution. Typical raster data is:
 - **GeoTIFF:** They have the file extension of *.tif. The key difference between normal TIFF file and GeoTIFF is that GeoTIFF has projection information. Hence, normal TIFF files cannot be correctly added to the desired location.
 - **GeoJPEG:** Similar to GeoTIFF, but they have *.jpg extension.
 - **Usage:** Raster data can be air photos, satellite images, elevation data (DEM). But raster data tends to be huge and slow to load.
- **Stronger Database Support:**
One major advantage of QGIS over ArcGIS lies in its superior support of different database vendors. Almost all types of relational database management system (RDBMS) are supported

1.2 Add a Basemap

1.2 Add a Basemap - Loading Goggle Maps

QGIS provides the flexibility of using Google (or Yahoo, Bing etc) Satellite images as a background layer in your map. These come in the form of external Plugins.

To add a Basemap, go to **Plugins -> Fetch Python Plugins**, which leads to a dialog.

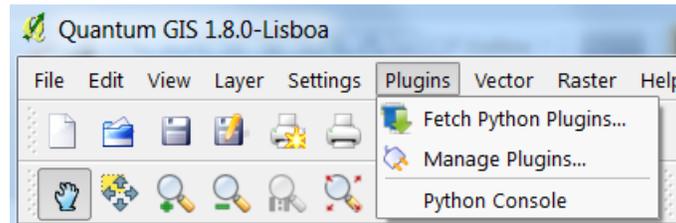


Figure 5. Steps to add a Basemap layer

Switch to the **Repositories** tab to ensure connection to the “QGIS Official Repository” have been established. Switch back to the **Plugins** tab and search for Openlayers (this can be done by typing “openlayers” in the filter), then select the “Openlayers plugin” and click the **Install Plugin** button.

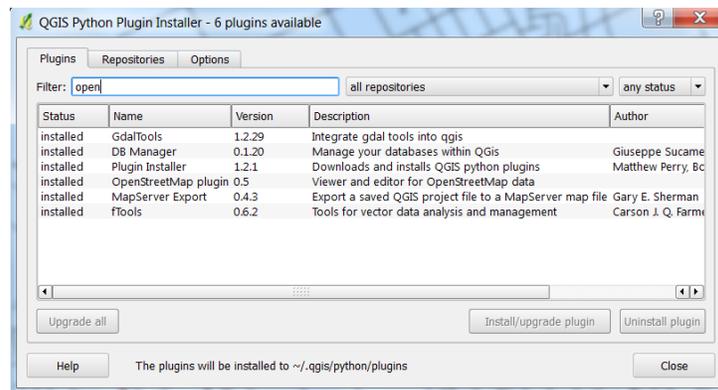


Figure 6. Plugin Installer Window

Go back to menu **Plugins -> Manage Plugins** to ensure the plugin have been selected. Once selected, maps for this external extension, such as Google map layers, can be selected in the menu **Plugins -> Openlayers plugin**.

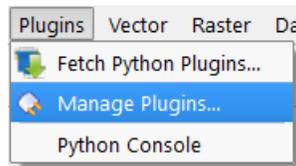


Figure 7. Manage Plugins in Menu Bar

*Please note there will not be Base maps in the Figures of this tutorial.

1.2 Add a Basemap



Brief introduction to geographic information:

- Vector Data: Vector data contains two parts: a geographic feature on the map (i.e. bus stops) and an associated record in the table with all its attributes (i.e. routes, arriving times, etc). The separation of attribute table and geographic feature is critical, because most operations in ArcGIS are organized based on this classification.
- Raster Data: Raster data is a set of cells with values, which is normally added as reference background in mapping or included for further analysis. Normally, users will not identify or modify raster data for mapping purpose.
- Networks: A kind of typical networks is roads. Finding the nearest way to a destination via roads is a frequently used operation. Please find more in the further reading if interested.
- Further Reading: Michael Zeiler, Modeling Our World, ESRI Press, 2nd Edition, 2010.

1.3 Browse Geographic Features

1.3. Browse Geographic Features

Most controls to browse data are located in two tool bars (Figure 8), which are also available under the **View** menu. If you cannot find this toolbar, go to **View -> Toolbars** and check the **Map Navigation** on.

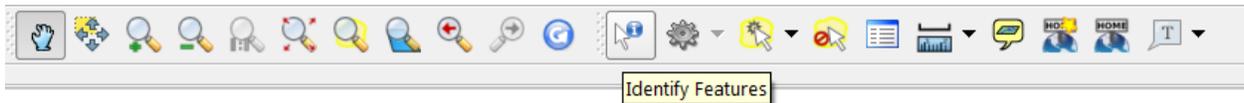


Figure 8. The Toolbar with Data Browsing Controls

Most icons are intuitive and self-explained. If you are not sure what function it has, hover your mouse over that icon. A pop-up text will show with further explanations.

One difference between QGIS and ArcGIS is the layer related operations. In QGIS, all layer related operations must be conducted after the target layer has been selected, such as feature identification, feature selection, and attribute table operations.

To open the attribute table, you can either right-click at the layer and select **“Open attribute table”**, or click the open attribute table button in the toolbar (Figure 9).

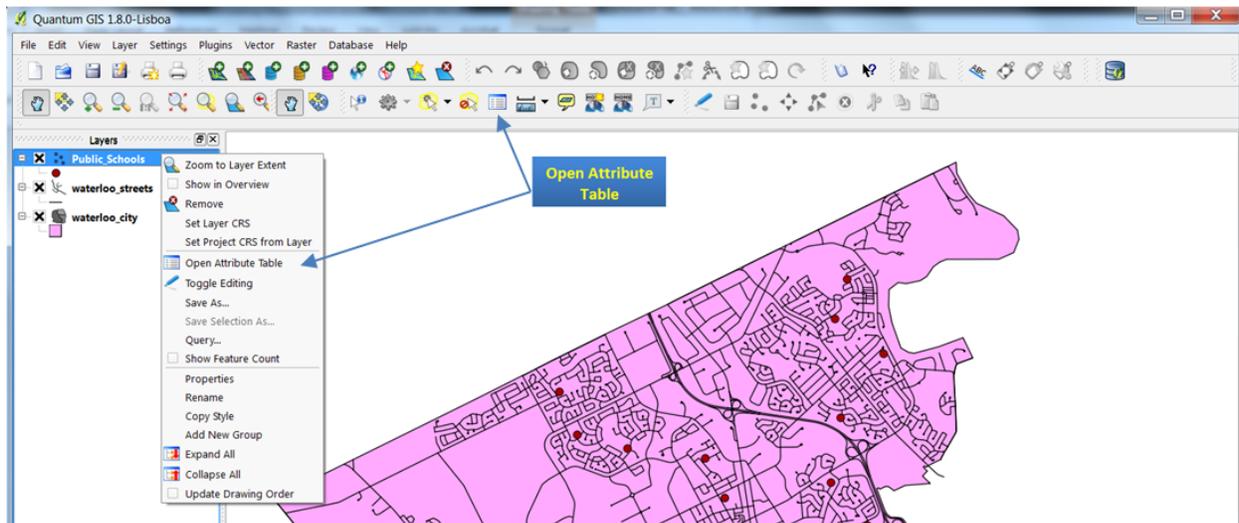
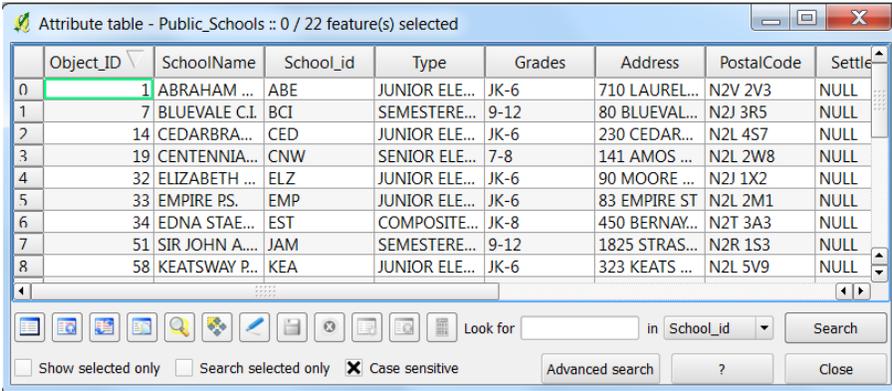


Figure 9. The Pop-up Window with Options on a Layer

1.3 Browse Geographic Features



Attribute table - Public_Schools :: 0 / 22 feature(s) selected

Object_ID	SchoolName	School_id	Type	Grades	Address	PostalCode	Settle
0	1 ABRAHAM ...	ABE	JUNIOR ELE...	JK-6	710 LAUREL...	N2V 2V3	NULL
1	7 BLUEVALE C.I.	BCI	SEMESTERE...	9-12	80 BLUEVAL...	N2J 3R5	NULL
2	14 CEDARBRA...	CED	JUNIOR ELE...	JK-6	230 CEDAR...	N2L 4S7	NULL
3	19 CENTENNIA...	CNW	SENIOR ELE...	7-8	141 AMOS ...	N2L 2W8	NULL
4	32 ELIZABETH ...	ELZ	JUNIOR ELE...	JK-6	90 MOORE ...	N2J 1X2	NULL
5	33 EMPIRE P.S.	EMP	JUNIOR ELE...	JK-6	83 EMPIRE ST	N2L 2M1	NULL
6	34 EDNA STAE...	EST	COMPOSITE...	JK-8	450 BERNAY...	N2T 3A3	NULL
7	51 SIR JOHN A...	JAM	SEMESTERE...	9-12	1825 STRAS...	N2R 1S3	NULL
8	58 KEATSWAY P..	KEA	JUNIOR ELE...	JK-6	323 KEATS ...	N2L 5V9	NULL

Look for in School_id
 Show selected only Search selected only Case sensitive

Figure 10. Attribute Data Window

There are many ways to choose a subset of features. Some options can be seen by clicking  , where the pop-up window displays different methods of feature selection (Figure 11).

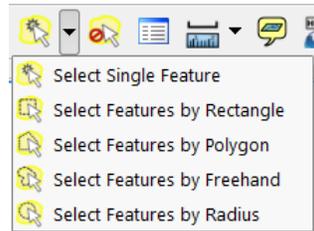


Figure 11. Selecting Features Options

Another way is by right-clicking the layer, then selecting “Query” (Figure 12). You can form SQL statements to select features based on attributes.

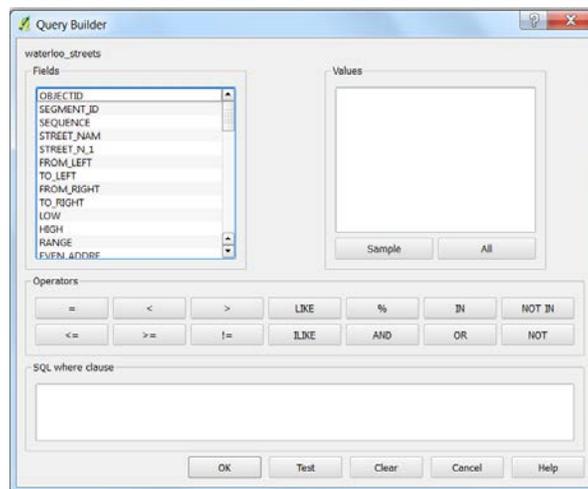


Figure 12. The Query Builder Window

Another interesting feature is “Zoom to layer extent” shown in Figure 8. Sometimes you may lose sight of your map display. If so, you can zoom back to the desired region by clicking **Zoom to layer extent**.

2.1 Distinction between Geospatial Data and Map Components

2. Mapping

2.1. Distinction between Geospatial Data and Map Components

Similar to ArcGIS, the mapping process is divided into two categories: Data view, which allows data manipulation and representation (symbology), and layout view, which provides functionality (i.e. legend, north arrow etc) and prepares a map for printing.

- **Data view:** or the **map canvas** displays map layers and allows interaction with the map and layers through map tools. Some key operations include change of layer order, symbology customization, vector editing etc.
- **Layout view:** Unlike ArcGIS, the layout view in QGIS is a tool called “**Print Composer**”. It is not as sophisticated as Arc’s layout view however allows the creation of maps and addition of essential map elements that can be printed or published. (See section 2.3 Map Components).

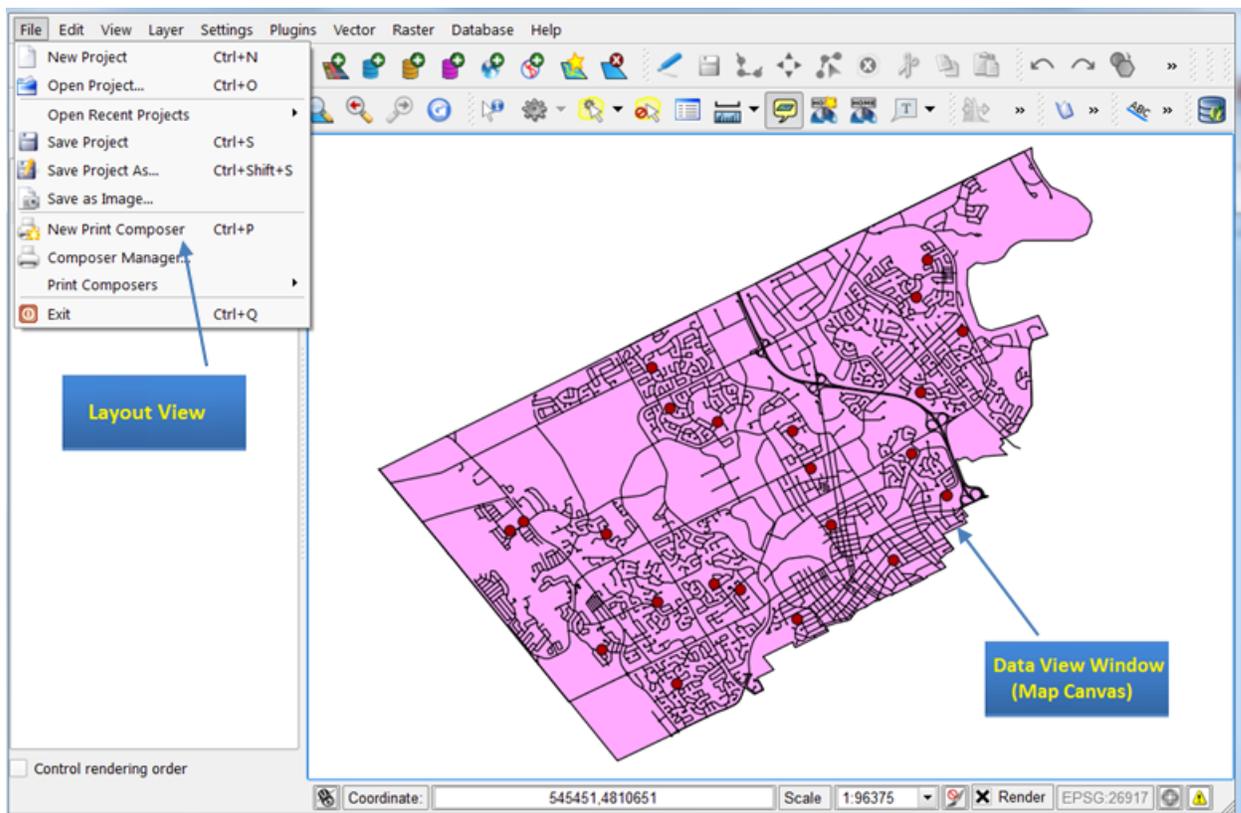


Figure 13. Switch between Data View and Layout View

2.2. Key Options of Geospatial Data Representations

2.2. Key Options of Geospatial Data Representations

Main options of changing geospatial data representations include layer order, layer transparency, symbology, label, and annotation. Apart from the first one (layer order) and last one (annotations), all the rest are located in the pop-up window when you right-click the layer (Figure 14) and select **Properties** to modify. They are under either the **Style** (symbology) or **Labels** tab (Figure 15).

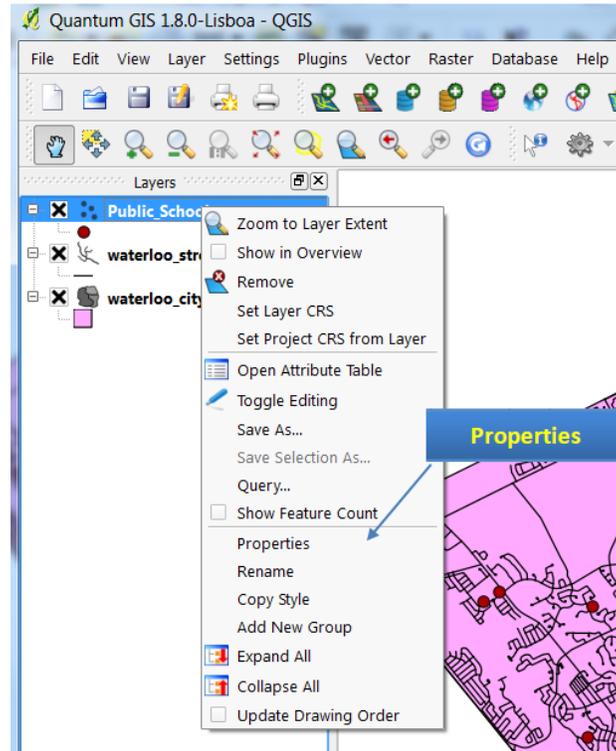


Figure 14. Pop-up Window of a Layer's Property

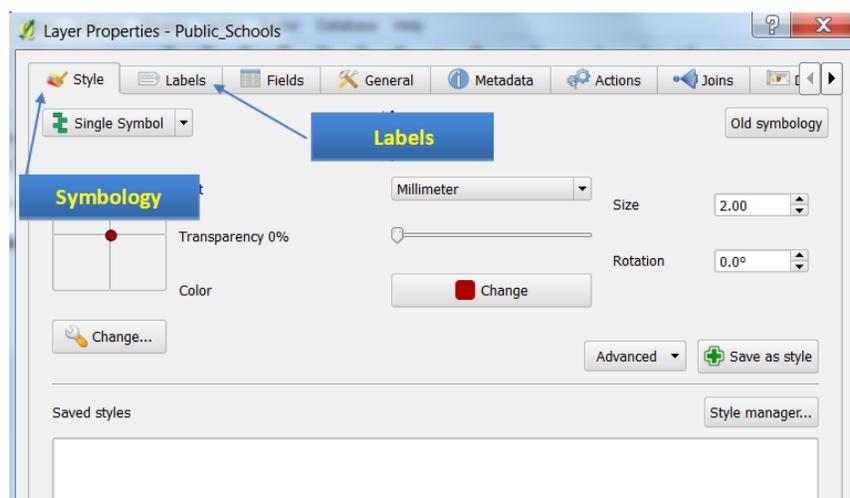


Figure 15. The **Properties** Window

All options will be introduced as subsections in the following.

2.2 Key Options of Geospatial Data Representations

2.2.1. Layer Order and Transparency

The boundary layer (waterloo_city.shp) can be made as “halo” (no fill color) polygons allowing the overlaying basemap to be visible. The detailed steps will be introduced after the concept of layer order. Please note however, Figures in this tutorial do not include basemaps.

Layer Order

QGIS displays geospatial data according to the order in the table of contents: the bottom layer will be drawn on the screen first and covered by upper layers. Hence, the layer on the top in the table of contents will be displayed as the top layer in the map. **Unlike ArcMap, QGIS will not order layers automatically.**

If two layers belong to the same feature class, i.e., point features, the newly added one will be on top of the older one.

When a point-feature layer is put under a polygon-feature layer, the point-layer feature one is covered and invisible. You can change layer visibility by switching the checkboxes left to the layer name in table of contents (Figure 16). The display order can be changed by simply dragging the layer toward or away from the top.

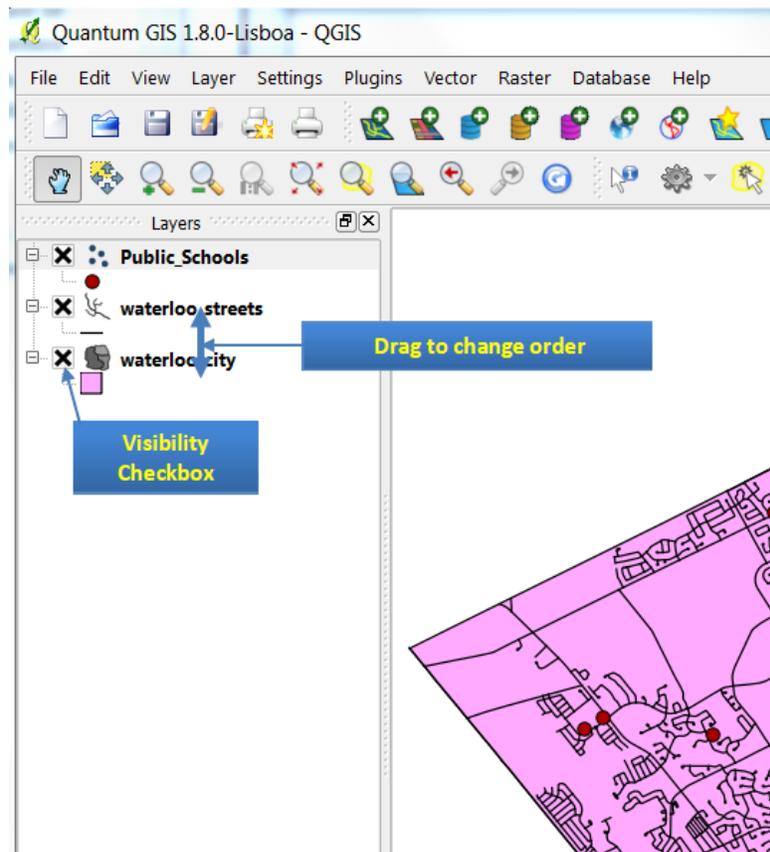
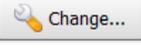


Figure 16. Layer Visibility and Order Control

2.2 Key Options of Geospatial Data Representations

Layer Visibility

When a polygon layer, such as buildings or parcels, is added over an image, the content on image under the building is often invisible. However users often like to only show the parcel's boundary and keep the image displayed. In this case, layer transparency and hollow symbology can help.

To do so, **right-click on the polygon layer** (waterloo_city) and select **Properties** first (Figure 15). Then switch to the tab **Style** and click  to get a pop-up window (Figure 17).

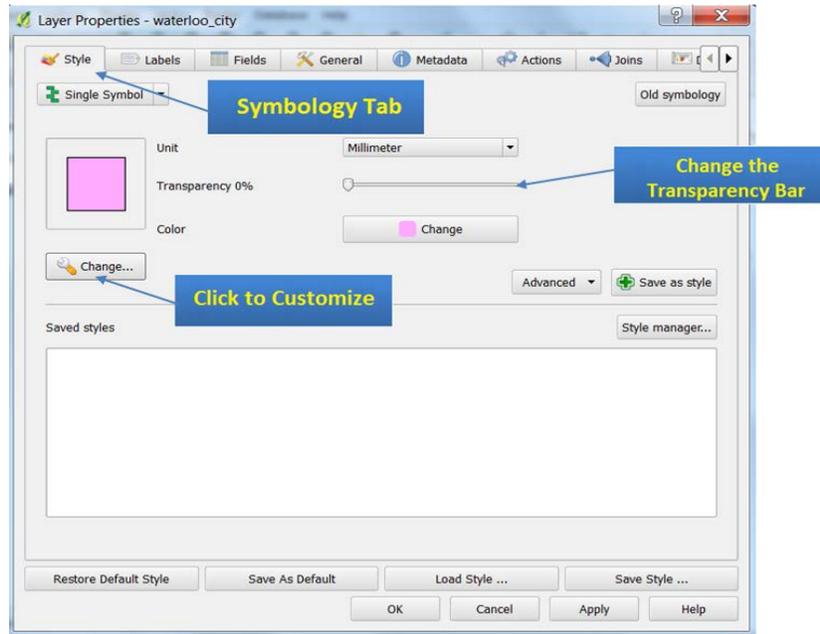


Figure 17. Properties of Symbology

When the pop-up window shows (Figure 18), you can make polygons hollow by changing **Fill Style** from Solid to No Brush, and increase **Border Width**.

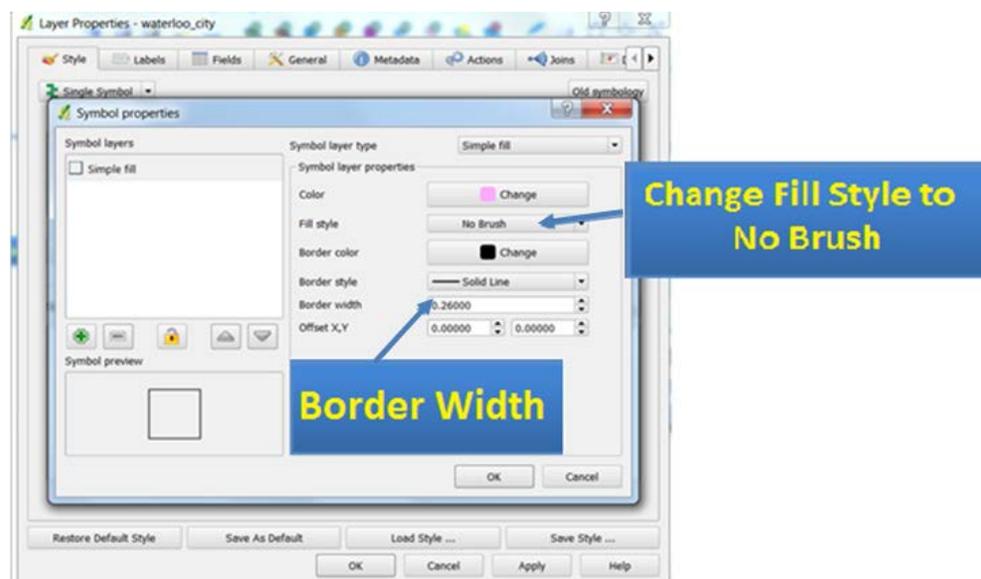


Figure 18. Make Hollow Polygons

2.2 Key Options of Geospatial Data Representations

2.2.2. Symbology and Label

Symbology is critical in making maps, which are classified into different categories in QGIS. Unlike ArcMap, QGIS does not hold a large library of professional symbols. In QGIS there are three types of symbols:

- Marker symbols (for points)
- Line symbols (for lines)
- Fill and Outline symbols (for polygons)

Each type of symbols can consist of one or more *symbol layers*.

Please right-click the **public_schools** layer and select **Properties**. Then switch to the **Style** tab and click on the  (Figure 17). The pop-up window contains several different elements.

Notice choosing different **Symbol Layer Type** will give different categorized symbols. In most cases, you will simply choose a symbol from the symbols available (other than making hollow polygons mentioned in 2.2.1). Depending on the type of the feature (point, line, or polygon) the options in **Symbol Layer Type** and **Symbol Layer Properties** change accordingly.

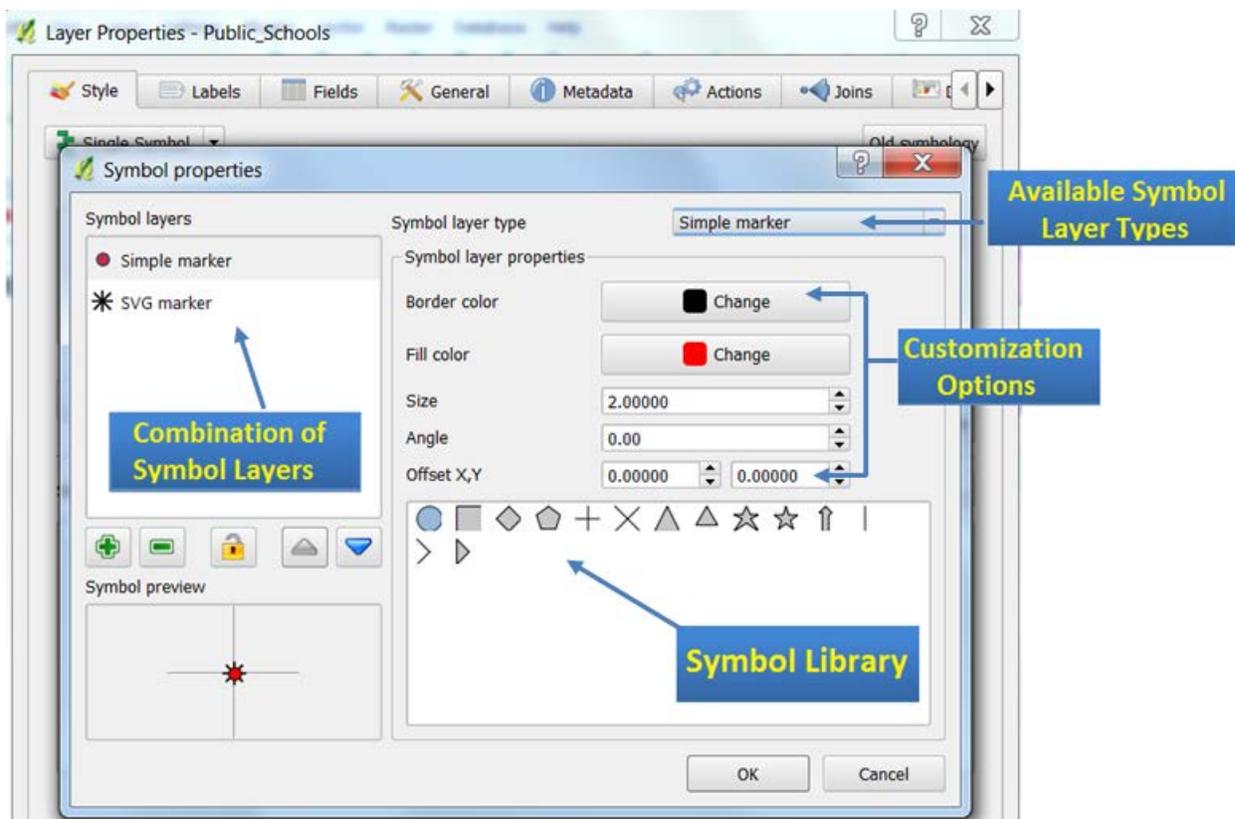


Figure 19. Symbology Customization Window with Explanations

2.2 Key Options of Geospatial Data Representations

Layer Transparency:

An alternative (more generic) way of preventing overlaying is right-click the layer and select properties (Figure 15) first, and go to the **Style** tab (Figure 17). You can freely change the transparency as the parameter (percentage) of “**Transparent**” (or “**Transparency**” for raster layers).

There are cases when you want to differentiate features in a layer based on some attribute. For instance, I want to know which schools are public, separate, or for higher education in the schools layer; different types will be marked in colors. To do so, we should **right-click** on the school layer, select **properties**, and go to the **Style** tab, which is the same as shown in Figure 17. However, instead of by-default **Single Symbol** option, we should click and select the **categorized** option. The steps to follow are also shown in Figure 20:

1. Click on **Single Symbol**, and make sure **Categorized** is chosen;
2. Pull down the dropbox of the **Column** field, and select TYPE as the classification attribute.
3. **(Optional)** Click on the **Color Ramp** and/or **Symbol** dropbox and select your favourite color scheme and appropriate symbol. This must be done *before* adding all distinct values in step 4.
*Note, some symbol layers (i.e. SVG Marker), have symbols that are color locked – meaning the color cannot be altered.
4. Click on the **Classify** button to add all distinct values under the TYPE attribute into consideration

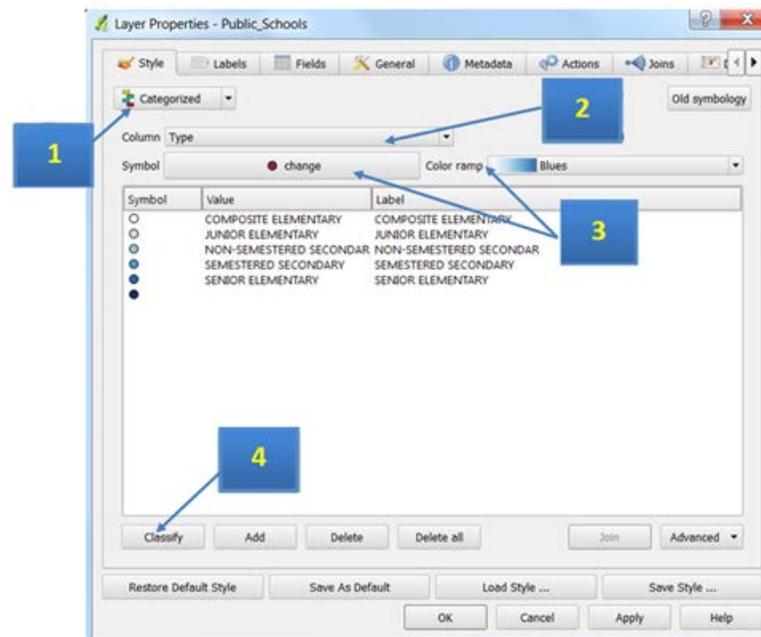


Figure 20. Classifying Features using Colors

The result is shown in Figure 21. Please note that you can still customize individual symbol for each category (size, shape, etc) by double clicking corresponding class on either the left pane or the line in the symbology window (Figure 21). The pop-up window is very similar to the window in Figure 20.

2.2 Key Options of Geospatial Data Representations

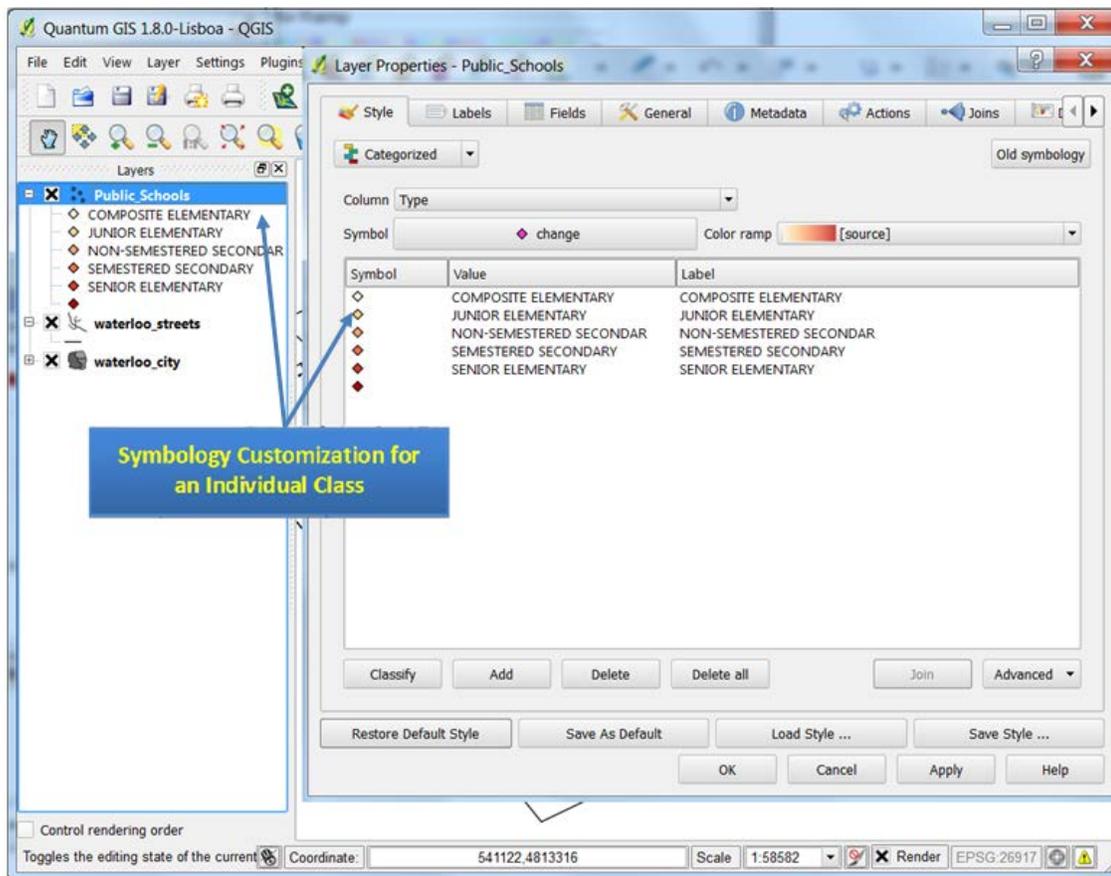


Figure 21. Classified Symbols and Further Customization

Labels

The labels are an important feature of a map. By marking some property up on the map, for stance, the name of the marked location, labels can make your map more useful, informative, and visually appealing.

To add labels to your map, **right-click** on the layer that you want to add marks on (Public_Schools) and select **Properties** (Figure15). Then follow the steps below:

1. Select the **Labels** tab and check on (off by default) “Display labels”.
2. Choose the attribute you want to display on the map in the dropdown of **Field Containing Label** (Figure 22).
3. Change **Font**, **Font Size** and other **Placement** options, so that it is clearly shown on the map.
4. **(Optional)** If you think the added labels are not distinct on the map background, you can make a buffer background around the texts. Please scroll down and check **Buffer Labels**, which have the same effect of “mask” in ArcMap (Figure 23)
5. You can click on the **Apply** button to see the effect until it is satisfactory. Then click on **OK** to save your setting and exit.

2.2 Key Options of Geospatial Data Representations

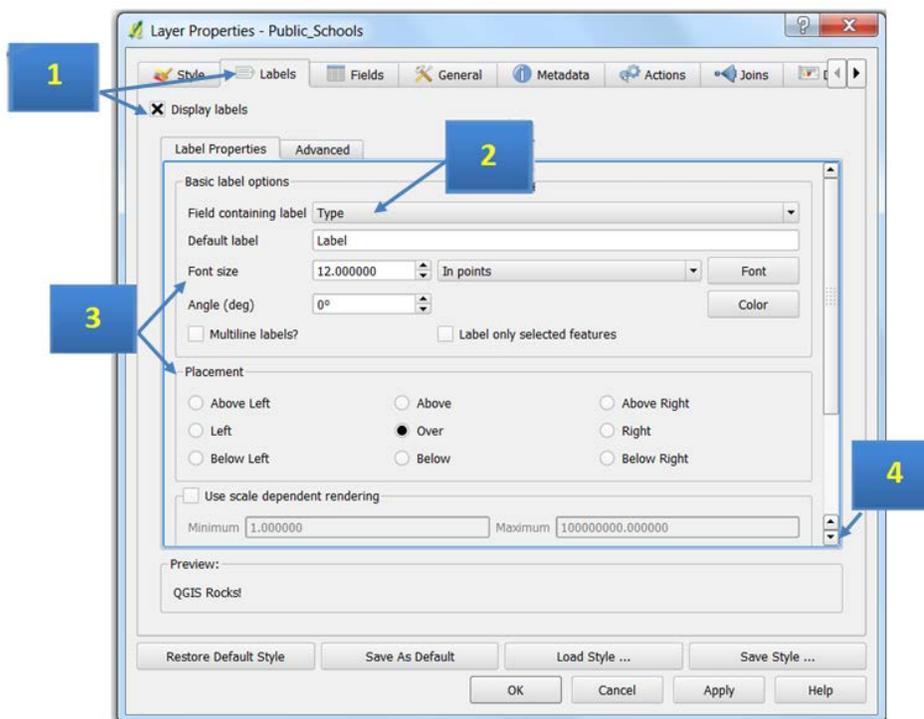


Figure 22. Label Setting Window

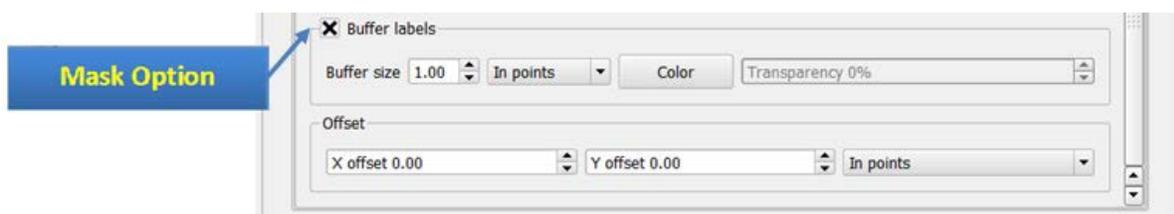


Figure 23. Change Mask Option for Clearer Labels

*Note: Alternatively, you can accomplish most jobs by clicking  in the toolbar. Only the “buffer” function is missing.

Symbology Types and Their Normal Usage

- Single Symbol: Mainly used when you just want to mark geographic features on a map.
- Categorized Symbol: also called *Unique Values*, gives every possible value of an attribute a distinct user-defined symbol (mainly based on colors). Categorized Symbol can be applied to all kinds of attributes.
- Graduated Symbol: Graduated symbol marked attributes with decretive numbers in a statistical way, which can only be applied to attributes with numbers.
- Rule Based: Condenses all the features from a layer with classification with rules that are based on simple SQL query language.
- Diagram Overlay: Unlike ArcMap, QGIS places multiple attribute mapping into an independent tab called **Diagrams**. Information like the percentage of populations in different age intervals at different locations can be easily shown in this way.

2.2 Key Options of Geospatial Data Representations

2.2.3. Annotations

Annotations look like Labels. The key difference is that annotation can be any text you want to add on the map, regardless to whether the information has been included in the geospatial data.

The tool can be found in the toolbar as shown in Figure 8.

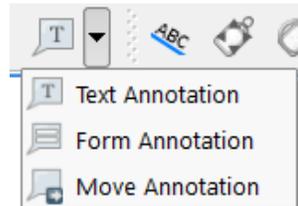


Figure 24. The Text Annotation Tool Options

For instance, if you want to add a point at the entrance of uWaterloo, which is not in the geospatial data, click on the **Text Annotation** tool and type in the label in the pop-up window (Figure 25)

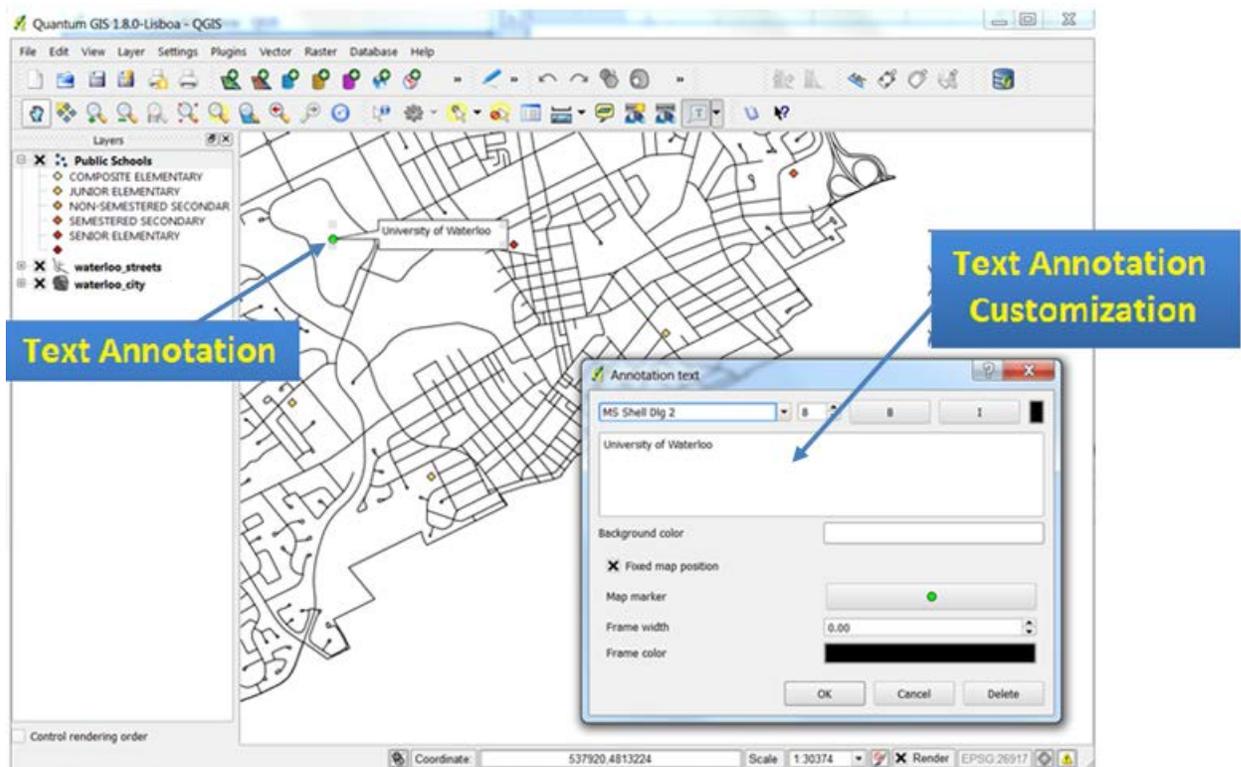


Figure 25. Text Annotation Customization Options

2.3 Map Layout Components

2.3. Map Layout and Map Components

When the geospatial data and its representations are satisfactory, you can add other map components in another window via **File -> Print Composer** (Figure 26). You can manage multiple composers via **File -> Composer Manager**.

Key components of a map include:

- The Title of the map (Purpose/Content);
- The scale of the map (Measurement);
- The North Arrow (Orientation);
- The Legend (how to interpret the map);
- (Optional) The reference (where you obtain the data).

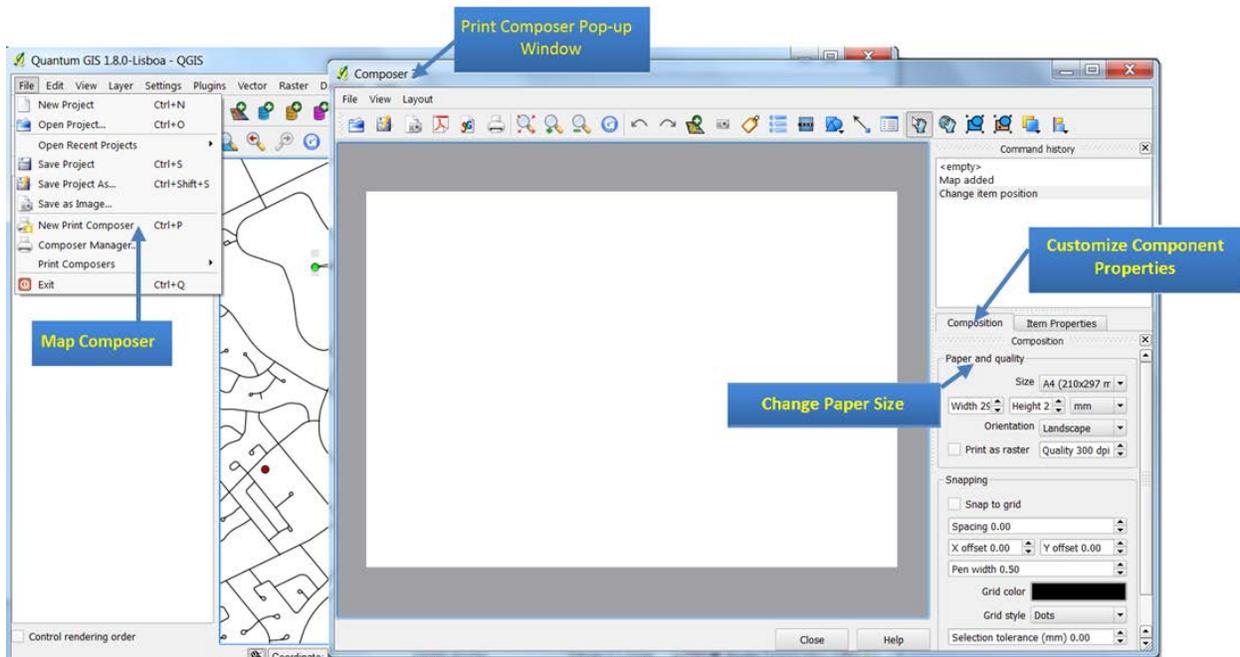


Figure 26. The Map Composer Window

Please note that, unlike ArcMap, the by-default page size is A4 (not letter size). Since letter size is more popular in North America, you might want to change the letter size, which is called “ANSI A” in QGIS.



(Figure 26) adds the Main Map, and is done by clicking and dragging a rectangle on the paper to define display area and extent.



Map Titles and Citations can be added by using this tool to create text boxes. Click to automatically create a text box and then click on the spot where you want to place the title at. Create a separate text box for citations.

2.3 Map Layout Components

In Print composer, you can customize the properties of all components by switching to the **Item Properties** tab. For instance, if you want to change the font of the title, click the title first (so that it is selected) and change to the **Item Properties** tab. There is a button called **Font** where you can find all the properties there.

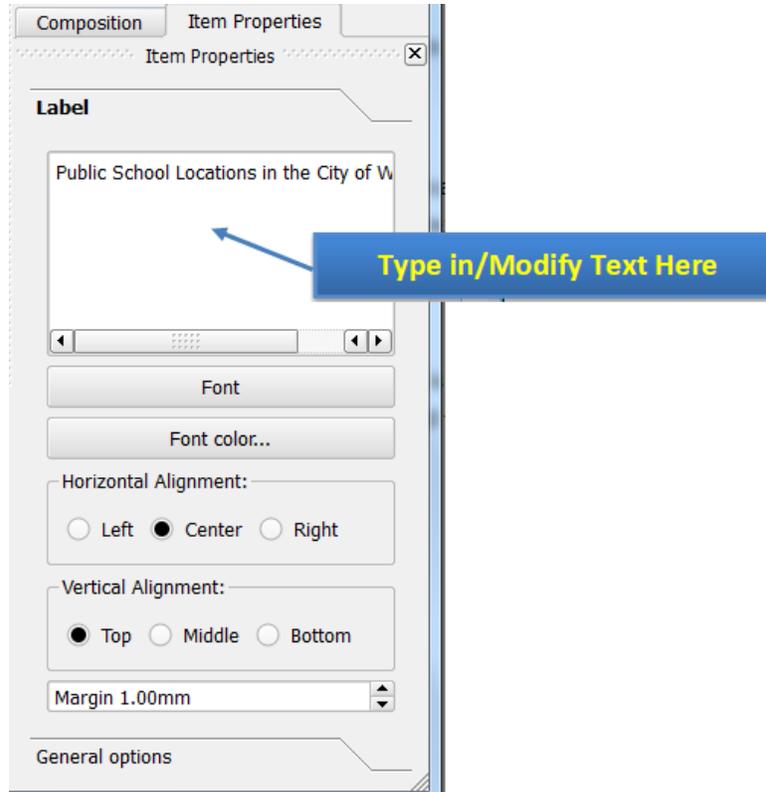


Figure 27. Text Box customization in Item Properties

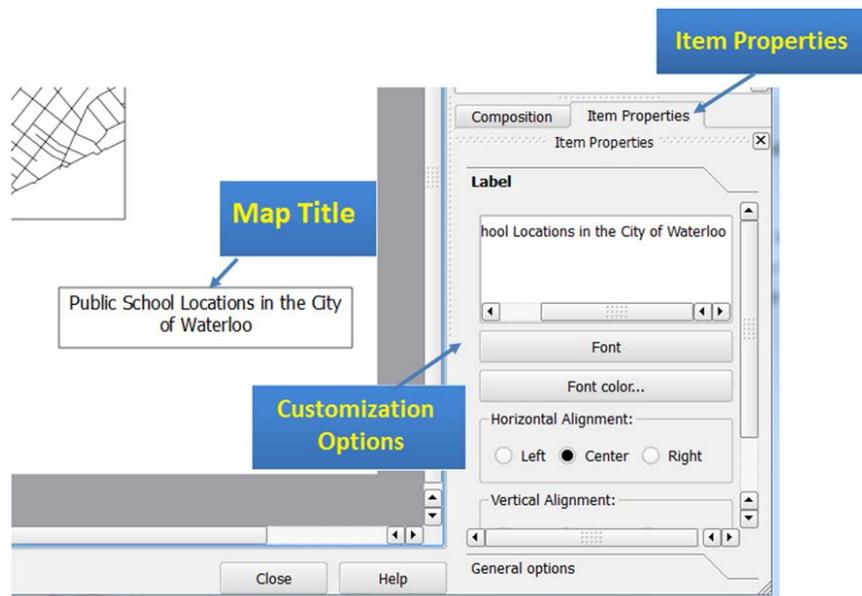


Figure 28. Customization in Item Properties Tab

2.3 Map Layout Components

 **Scale Bar**: click on the tool and then select the spot you want the scale to be. You can change **map units** and **Style**. The scale bar style can be numeric, i.e. 1:5,000,000, or different bar/line forms. All options are intuitive and can be tested by changing it back and forth.

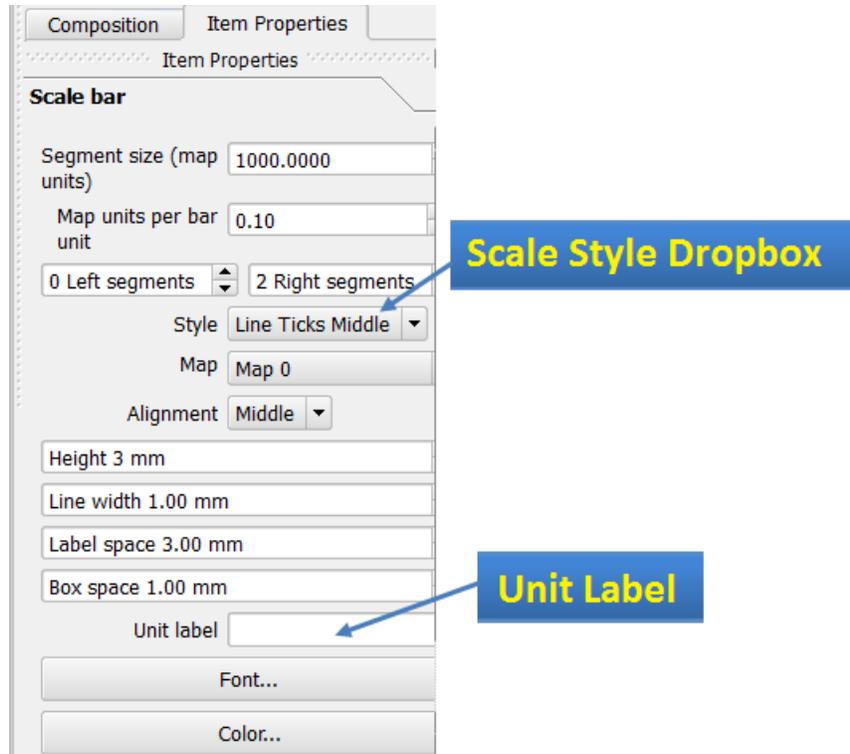


Figure 29. The Scale Bar (or Text) Property Window

 **North Arrow** can be added as an arrow. The options of a north arrow in QGIS are very limited.

 **Legend** can be added in the same way as others, click on the 'Add New Legend' tool. QGIS has better organization of legend properties than ArcMap. The Major options are located under **Legend items**. You can fine tune in **General Options** (Figure 30)

2.3 Map Layout Components

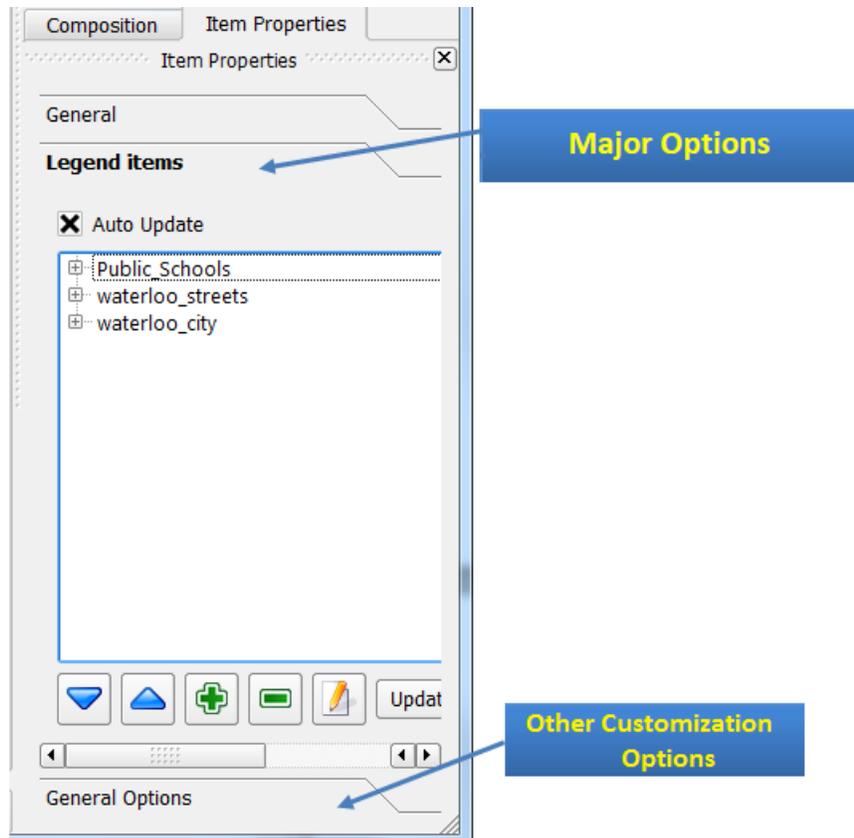


Figure 30. The Legend Property Window

The Legend tool automatically generates a legend based on all the layers available for the map – this is displayed in the **Legend Items**.

- **Add/Remove Layers:** You can decide the layers to be added to the legend by clicking  to add or  to remove.
- **Change the Display Orders:** The legend items will be added strictly in the order shown in the **Legend Items** pane. You can change the order by clicking a layer first and move it up  or move it down .
- **Change Layer Names:** It is easy to find that the name displayed in the legend is difficult to understand. For instance, users won't know what "waterloo_city" means. To change the name, you can select the layer, then click the edit button  and change it to a more meaningful name: City Boundary.

Another method is to **right-click** on the "waterloo-city" layer in the **table of content** pane (Figure 15), and click **Properties**. Switch to the **General** tab and change the name in **Display Name**. Creating a new Legend will update the layer's new name. *You can use either method to change "waterloo_streets" to "Roads".*

2.3 Map Layout Components

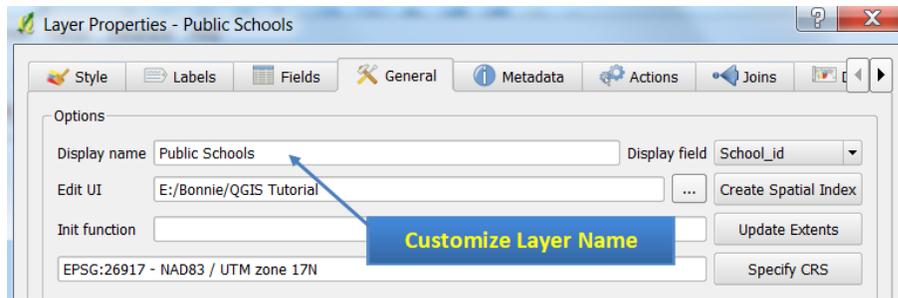


Figure 31. The General Tab to Change Layer Name

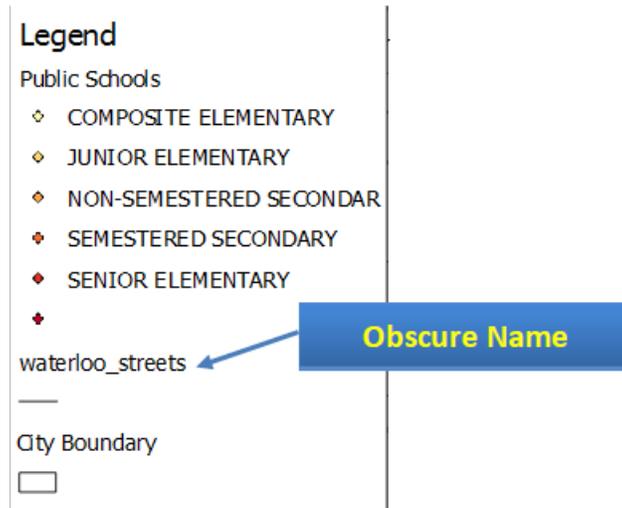


Figure 32. An Example of Legend after Customization



Some Components that are also frequently added:

- *Author of the Map:* Users may want to know who creates the map;
- *Data Saved (Created/Modified):* The more frequent a region changes, the more important it is for users to know when the map is created;
- *Coordinate System:* The globe is not flat, but a map is. Any kind of projection used to make the map distorts the reality in some way. Hence, it is critical for users to know how reliable their measurements on the map are, especially for pilots and navigators.

2.4 Export Maps

2.4. Export Maps

When you are satisfied with everything on the map and are ready to deliver, you can export your map as images, PDF, SVG, or print a hard copy. All options are under the **File** menu.

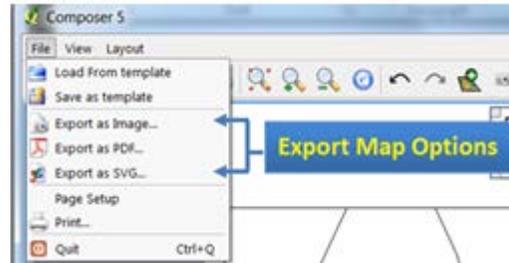


Figure 33. Export Map Options

You can specify the directory and file name of the map in this dialog. Most importantly, you need to choose an appropriate file format by clicking on the **Save as type** dropdown. The most frequent-used formats are JPEG and PDF. JPEG is a popular graphic file format, which is easy to be inserted into word as a graph, while PDF is best used for sharing. The printed copy of PDF will be identical regardless of your computer (and printer) environment.

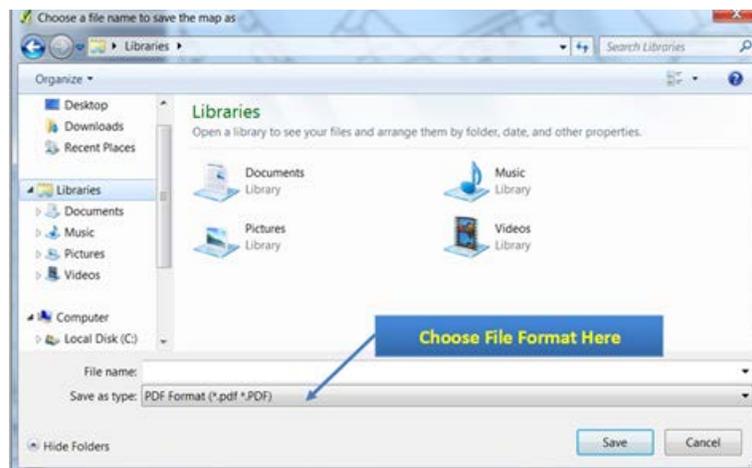


Figure 34. Export Map Dialog

Please note that if the purpose of your map is to be shown on screen, **96 dpi** resolution is good enough. It is especially true when you want to publish your map online, given that lower resolution maps are much smaller, and therefore, easier to transfer via Internet. If you need hard copies of your map, please make sure that the resolution is set to **300 dpi** or **600 dpi** (Figure 35). Otherwise the output map might be obscure.

2.4 Export Maps

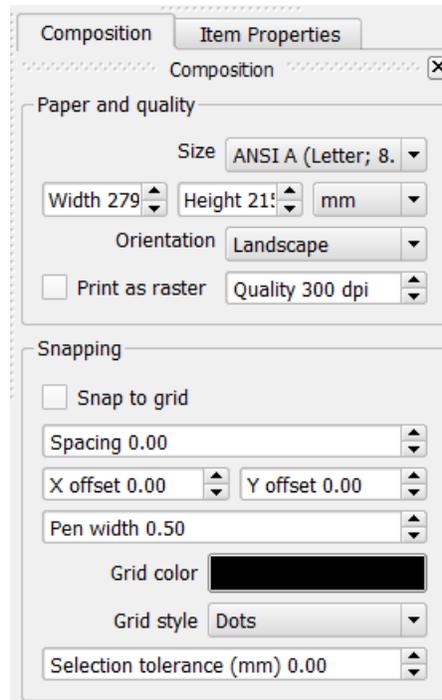


Figure 35. General Customization on Print Composer

Other than export map to other file formats, you can directly print out hardcopies of your map by **File -> Print**. You can also customize page and printer setup via **File -> Page Setup**, such as page orientation (portrait and landscape), page size and so on. All these operations are intuitive and very similar to other applications, such as Microsoft Word.

Brief Explanation of Graphic File Formats:

- **SVG file:** Scalable Vector Graphics, an open-source vector graphic standard. It is becoming more and more popular and can be accepted by many vendors;
- **BMP file:** BitMap file, which is a mature loss-less uncompressed raster format. The quality is great. But its file size tends to be huge. It can be used if you need both high-quality output and compatibility;
- **PNG file:** Portable Network Graphics, which is an open-source standard designed to replace BMP and GIF. It is a true-color loss-less raster file format. PNG file is slightly larger than JPEG (compressed with quality loss). And some old browsers and operating systems do not support PNG files;
- **TIFF file:** Tagged Image File Format. A major raster graphic file format provided by Adobe (AI for vector). Best to be used for raster file editing on Adobe Products, such as Photoshop;
- **GIF file:** Graphics Interchange Format. An uncompressed raster file format with 256-color limitation. Hence, if your map contains only a few colors (vector-based data), GIF is a good candidate.